

Dr Lucy Berthoud

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Present appointments

2018-present Professor of Space Systems, CAME School, University of Bristol **0.7FTE**
2012-present Senior Systems Engineer, Thales Alenia Space UK **0.2FTE.**

Previous appointments

2017-present Senior Teaching Fellow, CAME School, University of Bristol **0.7FTE**
2016-2017 Senior Teaching Fellow, CAME School, University of Bristol **0.6FTE**
2012-2016 Senior Teaching Fellow, CAME School, University of Bristol **0.4FTE**
2009-2012 Honorary Teaching Fellow, Aerospace Engineering, University of Bristol
2011-2012 Consultant Engineer to Thales Alenia Space UK
2006-2011 Science communicator at At-Bristol Science Museum
1995-2003 Systems Engineer in Mission Systems dept, Airbus Defence and Space
1996-1997 Royal Society Research Fellow at NASA Johnson Space Center
1993-1995 ESA Visiting Scientist Research Fellow at European Space Agency

Academic Qualifications

2018 Fellow of Royal Aeronautical Society
2017 Senior Fellow of Higher Education Academy
2014 Fellow of Higher Education Academy
1994 Chartered Mechanical Engineer, Institute of Mechanical Engineers
1993 PhD in Space Physics, ISAE (top French Engineering School), Toulouse
entitled: "Micrometeoroid and Orbital Debris observed in Low Earth Orbit"
1990 M.Eng in Mechanical Engineering (with Distinction), University of Bristol

Special Awards, Honours and Distinctions

2019 National Teaching Fellowship
2018 Nominated by students for Outstanding Teaching Award Engineering
2016 University Teaching Fellowship
2015 University Teaching Development Award
2015 Voted by students 'Best of Bristol' lecturer.
2014 University of Bristol Teaching Award for Engineering Faculty
[Worked in industry, then had health problems]
1996 Royal Society Fellowship to NASA Johnson Space Center
1993 Visiting Scientist Research Fellowship to European Space Agency
1990 PhD scholarship from EU under 'Science' programme.
1990 Rolls Royce prize for best student of Mechanical Engineering at UoB
1990 IMechE prize for best student of Mechanical Engineering at UoB.
1986 National Engineering Scholarship from Engineering Council UK.
1986 University Scholarship from BAe Space and Communications Ltd.

1. Teaching and related Administration

I believe that educational excellence should be at the heart of the University of Bristol and I encourage this at all levels in my work. I have led a series of ambitious initiatives designed to advance interdisciplinary problem-based learning at the University, including the University of Bristol Satellite programme and a flagship spacecraft team design project. I continue to push my faculty in the direction of allowing more interdisciplinary projects and partnership working, with students co-creating their own curriculum. My approaches are evidence-based and many of them are tested by my own research into teaching and learning (see section 2, Education research). I am a great believer in the uses of technology to enhance learning, where appropriate, and I have integrated many innovative methods including polling, 3D visualisation software and automatic formative assessment into my teaching. My teaching philosophy is to encourage students to engage with the subject themselves by inspiring them and then giving them stimulating opportunities to develop their skills. The opportunities I have established are based on case studies and applications from my experience as a professional space engineer in industry and at space agencies, including NASA and the European Space Agency.

1.1. Teaching Profile

I teach on 5 units in the Aerospace Engineering department and have designed, developed and delivered UG courses in Space Systems, Advanced Space Systems and Aerospace Systems engineering included in the table of teaching below:

Title/ Year of Study	Dates	No. of students	Methods	Contact hours	Assessment/ credits
<i>Space Systems 2</i>	2009-pres	150	Lectures, Laboratories and case study	150	Coursework 10% Exam 90% 10 CP
<i>Advanced Space Systems 4</i>	2009-pres	60	Lectures, Laboratories and case study	130	Coursework 40% Exam 60% 10 CP
Team design Project 4	2011-pres	90	Group project/ presentations/ technical reports	60	Coursework 100% 40 CP
Aerospace Systems Engineering 3	2011-2016	140	Group project/ presentations/ technical reports	30	Coursework 100% 10 CP
Individual research project 3	2012-pres	6	Individual project/presentation/technical reports	30	Coursework 100% 20 CP
Final year research project 4	2012-pres	4	Individual project/presentation/technical reports	30	Coursework 100% 40 CP
Tutorials yrs 1 and 2	2009-pres	4-6	Semi-structured tutorials w exercises	24	n/a

I am currently unit director for 20 Credit Points of courses, one of which is a core 2nd year course (*italicised* above). For these two courses, I teach 95% of Space Systems and 80% of Advanced Space Systems and am responsible for all coursework setting and marking, exam setting and marking, guest lecturers, coordinating laboratories and coordinating 5

postgraduate teaching assistants. I have received excellent feedback scores for these units. These and other sections of the cv has led to the following awards/invitations:

- **National Teaching Fellowship 2019**

This is a national level award. The University has 4 National Teaching Fellows, the last one awarded in 2016 and until now, none in the Faculty of Engineering. The purpose of the National Teaching Fellowship Scheme (NTFS) is to “recognise, reward and celebrate individuals who have made an outstanding impact on student outcomes and the teaching profession.”

- **Nomination for Outstanding Teaching Award 2018**

Nominated by students for an Outstanding Teaching award in 2018, with the following words:

“Students are clearly inspired by Lucy's teaching methods, which continue to surpass their expectations. Lucy uses innovative demonstrations to motivate students and encourage their independent learning. 'Although her lectures were mostly at 9am, it always felt worthwhile to attend as there was always positive learning from the lectures'. 'Lucy made every lecture interesting for her students, I can sense her passion about the subject she teaches and that inspired me to become a better engineer'.”

- **TEDx University of Bristol Talk 2016 “Is there Life on Mars?”**

TEDx Talks are invited short talks filmed by professionals and turned into influential videos from expert speakers on education, business, science, tech and creativity. My talk has been viewed 3200 times.

- **Best of Bristol Lecturer 2015**

In 2015 I was nominated as a 'Best of Bristol' lecturer by my students.

“The Best of Bristol lecture series showcase the most exciting and engaging lecturers and research at the University of Bristol, as chosen by our students, giving fellow students, university staff and members of the public a chance to experience the best teaching the University has to offer.”

- **Faculty of Engineering Education Award 2014**

This was awarded by the PVC for Education, Professor Judith Squires, at an award ceremony in 2014, with the following words:

“Lucy has done excellent work developing a research informed curriculum across a variety of units in Aerospace. She has cultivated high quality flagship units that extend the student experience, providing innovative opportunities and engaging the student body. Lucy also helps less experienced and recently appointed academic colleagues to develop their skills by offering advice, critical appraisal and insight into new practices from evidence informed approaches... Feedback from students has been particularly impressive and is supporting evidence that her engaging and stimulating teaching encourages students towards a deeper interest in the subject and to seek out careers in space engineering”.

- **Student Success**

The impact of my ideas and strategies has had a significant effect on the students, giving them opportunities which they could not have accessed previously. This has led to them achieving outstanding results: in the past 5 years more than 20 have gained positions in the highly competitive space industry (previous to my appointment at the University only 1 exceptional student every four or five years would go into the space industry), including 5 at the European Space Agency. 3 of our students have been

selected to represent the UK and then went on to be win prizes at the International Astronautical Congress - a highly prestigious 6000-person international space conference attended by space agency leaders and many astronauts.

1.2. Innovatory teaching methods introduced

- *Interdisciplinary projects across Engineering 2016-17* - I am driving an initiative to develop more interdisciplinary working for Engineering Faculty. This would enable students of all engineering disciplines to be able to work together on projects. It has involved working with the Faculty Senior Management Team, programme directors, accreditation bodies and timetabling to overcome the significant obstacles.
- *Wikis in team design projects 2011-13* - I used wikis to look at communication, collaboration and engagement in the 4th year team design projects using user contribution statistics and content categorisation in order to track engagement and types of communication. I published this work as an article in the highly regarded European Journal of Engineering Education.
- *Industrial 4th year Spacecraft team design project (2011-2015)* – From my experience in industry, I could see that students needed to experience an multi-disciplinary team design project, so I set up industrial link to Airbus Space division so that students could carry out spacecraft team design project vital for employability in the space industry. This involved liaising with Airbus to establish mission specification, learning objectives, modes of feedback and assessment.
- *3D visualisation laboratories 2013–17* - I teach 3D celestial mechanics/astrodynamics concepts which students struggle to understand, so I developed computer laboratories using NASA 3D software to help students visualise these challenging concepts. This was published as a paper for the 2017 European Engineering Education conference.
- *Blackboard automatic feedback quizzes 2014-17* – I wanted to improve feedback for students on my courses, so I developed a formative assessment automatic quiz system using Blackboard to aid student revision.
- *Polling software 2011-17* - I teach 150+ students in my Space Systems course and I wanted to check their understanding and help them interact more, so I use polling software in lectures.
- *Meta-learning coursework 2015-16* – In my courses, I wish to encourage students to develop their own reflective learning style, so part of their coursework now consists of asking them to research and explain the part of the course that they have found the most difficult (note that this is not graded). I can then correct any misconceptions in their understanding and personalise their feedback.
- *Gamification 2016-17* – In all my courses, I have incorporated game elements and thinking to improve learner's motivation, for example, by styling some revision classes on the 'University Challenge' TV quiz, complete with buzzers.

- *Built demonstration models 2014-17* – For all my courses, I have designed and had manufactured a number of lecture demonstrator models to illustrate key threshold concepts. My fire extinguisher and skateboard demonstration is now on YouTube.
- *Co-creation of coursework 2016-17* - in partnership with students from the Advanced Space course, I have developed new coursework on a mission to Jupiter.
- *Extra-curricular faculty-wide CanSat (satellite in a sodacan) competition 2016-17* – In 2016-17 I started an interdisciplinary competition to bring together students from different disciplines to work on simple satellites to be dropped by drones with a parachute. Students from this project have since been out on Outreach exercises to Science Museums and schools to talk about and demonstrate their hardware. They have also explained their work to the Vice Chancellor. With some support from me, the competition is now run by the student space society.

1.3. Collaborative Teaching Projects

- *Joint supervisor Physics 3rd year team design project (2017)* - set up industrial project link for Rutherford Appleton Laboratory Space to mentor 3rd year physics undergraduates to design, build and test an infrared camera for our Satellite project.
- *Space director for 4th year Aerospace team design project (2011-2015)* – set up industrial link to Airbus Space division so that students could carry out spacecraft team design project vital for employability in the space industry. This involved liaising with Airbus to establish mission specification, learning objectives, modes of feedback and assessment.
- *Supervisor 4th year research project (2014-15)* - with Airbus Defence and Space division on ‘Deployment systems for 50+ CubeSats’.
- *Supervisor 4th year research project (2012-13)* - with Surrey Satellite Technology Ltd on ‘Thermal control of nanosatellites’
- *Supervisor 4th year research project (2012-13)* – with Airbus Defence and Space Ltd on ‘Power and Thermal Design of Europa and Ganymede Penetrators.
- *Supervisor 4th year research project (2011-12)* – with Systems Engineering Assessment Ltd on ‘Ultra-Low Earth Observation Satellites’.

1.4. Postgraduate advising

I ensure that **my 4** post-graduate students present their own work as often as possible at seminars or conferences and work closely with industrial collaborators. I have **3** PhD students on industry iCASE EPSRC studentships: Jonathan Walsh (started 2015) and **Gary Sutlieff (started Sept 2019)** working with Thales Alenia Space and Joe Gregory (started 2016) working with Airbus Defence and Space. **Tom Etchells (started January 2019)** has a DTP studentship, I am principal advisor for all.

1.5. Major achievements in Teaching Administration

As unit director for 20 credits of high contact time, highly integrated and multiple activity Space Systems and Advanced Space Systems courses, I have successfully increased feedback and uptake of the courses by incorporating many innovative methods for promoting student engagement and reflective learning. Despite increasing student numbers and pressures on resourcing, I have maintained the highest standards of educational excellence for the students, as attested by high feedback scores and 3 prestigious awards for teaching/speaking. Whilst teaching on 5 units in the Aerospace Engineering department, I have incorporated the latest thinking in both spacecraft design and research in engineering education. I supervise postgraduates and have established many joint projects with the top space companies. These opportunities have resulted in a significant increase in UoB students going into space careers and winning international competitions for their research.

2. Education Research and related administration

It is my belief that incorporating research and scholarship into everyday teaching and learning supports educational excellence. My pedagogical areas of research started with my technical field: spacecraft design. Outside my University of Bristol work I am a professional Space Systems Engineer, managing space mission design projects for a large spacecraft manufacturer – Thales Alenia Space UK. A few years ago, I noticed that some graduates were coming into our company with experience of a new type of project: a “CubeSat” build. Their European University had given them the opportunity to build an actual satellite and launch it. This gave them a major advantage over any other job applicants as they had designed, built and tested a satellite themselves in a team. I felt strongly that our students at the University of Bristol should be offered the opportunity to work on a similar collaborative multi-disciplinary project, as it is vital preparation for working in industry. Working on a real-life space mission brings excitement and prestige to the students and to the University. This is why I started the University of Bristol Satellite programme in 2014.

I was awarded a University of Bristol Teaching Development Grant in 2015 to provide funding for travel to several CubeSat conferences to discover best practice for setting up a CubeSat project. As part of this I initiated a study with 45 Universities across the world to discover what issues they had with project managing their CubeSat satellite builds. One issue raised by many CubeSats was the difficulty and challenge of passing information and expertise between successive years of students and across departments.

To overcome these challenges, I was awarded a University of Bristol Teaching Fellowship in 2016 (the only one of the year) to implement a Community of Practice approach to running the University of Bristol satellite project. This is a ground-breaking way of approaching a multidisciplinary multi-cohort technical project. I am also raising the profile of the University of Bristol in the area of Space research and education via my publications on this project. More than 65 students and staff are now working on a real spacecraft mission (including operating a ground station), they are exchanging knowledge with other

community members, sharing best practice through peer to peer learning and the staff and students participate in the learning community together. Through this project, the University of Bristol gains a high prestige technology project and a seat at the top table in UK Space Research - only the top UK Space Universities such as Imperial, Southampton, Cranfield, UCL are building CubeSats. In 2019, we were selected for a £1.2M of free bus and launch by Lockheed Martin and our CubeSat is scheduled for delivery of our payload in October 2020 and a launch in mid-2021. This has meant forming a crack team of undergraduates, postgraduates and staff to ensure fast progression of the development. There are 25 students and 6 staff working on this project.

The University's profile in educational research is raised through my leading the Engineering Education Research Group, by being a National Teaching Fellow, my 12 Engineering Education Journal/ Conference papers and by my presence at Engineering Education conferences, including those that I am on the organising committee for.

2.1. Scholarship of Teaching and Learning

- *Head of [Engineering Education Research Group](#) (2018-present)*
At the request of the Dean, I set up and lead the Engineering Education Research Group. This now has 52 members, a working committee of 6, 3 research themes with leaders, a series of seminars (which I organise), a series of Teaching Excellence forum talks (which Joel Ross organises), a website and 43 Eng Ed related publications by members since its formation. It has recently been recognised as a fully fledged research group by the School Research committee, which I sit on as Head of Group.
- *IEEE Educon 2020 organising committee* – reviewing papers for this conference and serving as a member of the committee.
- *Publishing* – I have published 2 journal and 6 (+4 more since being promoted) conference papers on engineering education, CubeSats and communities of practice. This includes being lead author of a journal paper by the Space Universities Network on the development of the Network and its goals and benefits. I have also written a case study on the use of social media for team projects for the Digital Education Office best practice website.
- *Senior Fellowship of the Higher Education Academy (2017)* - this is increasingly used by H.E. institutions as a criterion for promotion. According to the HEA: “this qualification is awarded upon evidence of influencing other colleagues’ professional practice in a higher education career; it demonstrates commitment to teaching, learning and the student experience, through engagement in a practical process that encourages research, reflection and development.”
- *University of Bristol Teaching Fellowship (2016-19)* – The University of Bristol offers a prestigious 3-year Teaching Fellowship with (£10K funding). I received this to research the use of Communities of Practice in University Satellite programmes. I have been mentored in this research by Professor Sarah Baillie, Principal Fellow of the HEA and National Teaching Fellow. See section 2 introduction.

- *University of Hereford Education Advice* (2016) - I was invited to represent the University of Bristol to advise in the setting up of a new University of Engineering at Hereford, NMiTE. This involved advising on curriculum, pedagogical methods and assessment. The University will open in 2020.
- *Faculty Learning Community (FLC) member* (2016-17) – I am a leading member of the first University of Bristol FLC, a community of engineering pedagogy scholars who committed to work and reflect together on teaching and learning projects over a year. This forms part of my commitment to scholarship and to supporting early careers colleagues in their engineering education research.
- *Teaching Excellence seminar* (2016)– invited to give a seminar on “The use of wikis in team design projects” as part of the Teaching Excellence series.
- *University of Bristol Teaching Development award* (2015-16) - This was awarded to research best practice in setting up a ‘CubeSat’ project. This involved working with 45 Universities across the world to find out best practice and advice in setting up CubeSat project, i.e.: equipment needed, where to start, how much it cost, what the most challenging aspects were etc. I presented this as a paper for the prestigious SmallSat conference Education session in August 2016. It has since been downloaded 200 times.
- *Member of Royal Academy of Engineering Focus group on Teaching and Learning* (2015) - Contributed towards the report “[Does teaching advance your academic career?](#)” by Dr Ruth Graham through contributions during panel discussions.

I have *italicised* those publications which are specifically to do with my Engineering Education research. **Those below have been published since my promotion to Professor in August 2018, the rest can be found in Appendix A.**

2.2. Journal Publications (since promotion to Professor)

1. Gregory, J. R., **Berthoud, L.**, Tryfonas, T., Rossignol, A. & Faure, L.,(2020), The long and winding road: MBSE adoption for functional avionics of spacecraft, *Journal of Systems and Software*, 160, 110453 (10%)
2. Gregory, J. R., **Berthoud, L.**, Tryfonas, T., Prezzavento, A. & Faure, L., Investigating the Flexibility of the MBSE Approach to the Biomass Mission, *IEEE Transactions on Systems, Man, and Cybernetics: Systems*. In press (10%)
3. Wood, K, Richardson, T, **Berthoud, L.**, Watson, M, Thomas, H, Naismith, A, Lucas, J & Calway, A, 2018, ‘3D Reconstruction of Volcanic Ash Plumes using multiple ground based infrared cameras’., *ISPRS Journal of Photogrammetry and Remote Sensing*. 154, p.163-175 (5%)
4. Wood, K, Albadra, A, **Berthoud, L.**, Calway, A, Watson, M, Thomas, H, Richardson, T, Liu, E. & Chigna, G. (2019) “Determining the three-dimensional structure of a volcanic plume using Unoccupied Aerial System (UAS) imagery”, *Journal of Volcanology and Geophysics Research*, In press. (10%)

2.3. Conference Publications (since promotion to Professor)

1. **Berthoud L.** and Lancaster S. “Work in Progress: Curriculum Review for Rocket Scientists”, *IEEE Educon*, April 26-30, 2020, Porto (50%)

2. **Berthoud, L., Swartwout, M., Cutler, J., Klumpar, D., Larsen, J. & Nielsen, J. D. (2019) “University CubeSat Project Management for Success”, 33rd Annual AIAA/USU Conference on Small Satellites SSC19-WKIII-07. Utah State University (90%)**
3. **Berthoud, L. Glester A. et al. (2019) Spicing up your space education with cansats, rockets and hackathons - the SUN Recipe Book, 3rd Symposium on Space Educational Activities, September 16-18, 2019, Leicester, United Kingdom. (60%)**
4. Gregory, J, **Berthoud, L**, Tryfonas, T & Prezzavento, A, (2019), “Early Validation of the Data Handling Unit of a Spacecraft Using MBSE” 2019 IEEE Aerospace Conference, AERO 2019: 2-9 March 2019, Big Sky, MT, USA. IEEE Computer Society, Vol. 2019-March. 8741767 (10%)
5. Andrews, S & **Berthoud, L**, (2018), ‘Modelling and Characterisation of Plasmadynamic Drag on Gridded Ion Engine Propelled Spacecraft in Very Low Earth Orbit’. in: *Proceedings of the 69th International Astronautical Congress 2018, 1- 5/10/18 Bremen, Germany*. International Astronautical Federation, IAF (10%)
6. **Berthoud, L & Glester, A**, (2018), ‘Space Universities Network - supporting the Space Science and Engineering Higher Education Community in the UK’. in: László Bacszárdi (eds) *Proceedings of the 2nd Symposium on Space Educational Activities: April 11-13 2018, Hungary, Budapest at Budapest University of Technology and Economics. Budapest University of Technology and Economics*
7. **Berthoud, L**, Pugh, K & Schenk, M, (2018), ‘Setting up a Community of Practice for a University CubeSat Project’. in: *Proceedings of the 46th SEFI Annual Conference 2018 - Creativity, Innovation and Entrepreneurship for Engineering Education Excellence, SEFI 2018. European Society for Engineering Education (SEFI) (90%)*

3. Academic Leadership and Citizenship

My current roles include being Chair of the First Year Curriculum Review Board, Chair of the UK Space Universities Network, director of the University of Bristol Satellite programme, director of the University of Bristol Satellite Laboratory and Ground Station, Deputy Programme Director for the Aerospace Engineering programme, a member of the Faculty Undergraduate Studies Committee and a member of the new Bristol Institute for Learning and Teaching steering group committee. Previously, I ran a series of University of Bristol Space research workshops to unite members of the University with space research interests. I have redesigned our department tutorial system and been a leading member of the CAME School successful Athena Swan submission for a Bronze award. As well as offering both formal and informal mentoring for early career colleagues, especially those on a Teaching Pathway, I also started a Teaching and Education forum for the Engineering Faculty. This is a platform for the talents and experience of our senior staff and education innovators, which at the same time offers support and training for new and existing staff. I have now mentored a talented Pathway 3 colleague, Dr Joel Ross, to take it over.

3.1. Academic Leadership in the discipline

- **Chair of First Year Curriculum Review Board, CAME school (2018-present)**
This is an ongoing project to deliver a full first-year curriculum review. A board has been formed of which I am the chair, I have directed 5 working groups to look at data, literature, benchmarking against other Universities, how we can improve transitions and assessment to deliver some clear recommendations within the pedagogical framework of constructive alignment. With the project manager, Sean Lancaster, I have run 4 awaydays for staff and also communicated on the project to the SMT, the School and the staff affected. This is the most major curriculum project the School has undertaken for the past 20 years and has involved liaison with AQPO, SCEEM school, the languages depts, BILT, Engineers Without Borders (for a project), critical friends from other University departments, the Pro-VC for Education, from outside CAME and,

most importantly, the approximately 30 staff involved, their programme directors and their Heads of department. Pilot projects will be delivered in 2020 and, despite numerous challenges, it is currently on track for full rollout in Sept. 2021.

- *Chair of [Space Universities Network](#) (SUN) (2015-present)*

I have chaired the Space Universities Network (SUN), since it started, with the aim of promoting the sharing of teaching and learning best practice in the Space Science and Engineering Higher Education Community. When I was a member of the Royal Academy of Engineering focus group on Teaching and Learning, we discussed how we could raise the level of Space Education in the UK by sharing ideas and resources. I formed the Space Universities Network (SUN) in 2015 with two colleagues from other Universities. The aim was to bring together members of the UK Space HE community to exchange knowledge, so that together we could inspire more students to join the space sector and ensure they are equipped to contribute. SUN shares and promotes effective practice and innovation in the delivery of university-level space science and engineering curricula through:

- creation of a curated web-based repository of shared resources to support teaching including case studies, class resources, question bank, shared facilities and recommended guest lecturers.
- liaising with industry to ensure relevance of curricula.
- hosting regular workshops to promote discussion. These are themed and have covered a review of best practice, how to link with industry and the future of space education in the UK.
- promoting space science and engineering as a discipline and as a career through careers advice and postgraduate and summer courses.

As I am the chair of the Network, it is hosted by the University of Bristol, which brings prestige to the University (the University also hosts the extremely successful Economics Network, chaired by Prof Alvin Birdi, who has mentored me through the formation of this network). I have raised money from the UK Space Agency to support SUN, recruited 2 staff to run it and have organised and chaired workshops and regular meetings of the working group. It was launched officially at the UK Space Conference 2017 ([see press release](#)) with 50 members of academia, industry and students present. The organisation now has 44 members from 28 HE institutions, including the top Space Universities in the UK. I and my team run all the events, the website and coordinate the network. I recently chaired a SUN session at the UK Space Conference to bring together engineering companies and space academics in a joint workshop entitled: "What does the Space Industry want from graduates?" (the talks are now on YouTube). Professor Alison McMillan of Wrexham Glyndwr University, one of the members of SUN, wrote afterwards: "*I would like to congratulate you again, for the excellent work you have done to set up the Space Universities Network. I have been really impressed with your vision and leadership and the level of support that you have thus far generated.*"

- *Director of University of Bristol Satellite Programme (2014-present)*

I have initiated the University of Bristol Satellite programme which is a multi-disciplinary high-prestige programme to excite and inspire students. I ran a payload announcement of opportunity across the University and established and chaired a payload review panel of senior academics to select payloads to develop for the satellite. I have recruited 10 members of staff and together we have recruited 65 students to work on

projects linked to the UoB Satellite Programme embedded within the curriculum. To improve practical and design skills for this, I started an annual competition in tandem with a student society (Students for the Exploration and Development of Space) to launch simple satellites in a sodacan from a UAV.

- *Director of Satellite Laboratory and Ground Station (2014-present)*
I have led and coordinated the creation of a £100k satellite laboratory and ground station to support the University of Bristol Satellite programme. UoB is the first in the South West region to have a satellite lab and ground station, allowing students in the department of engineering hands-on access to the cutting-edge tools used for space exploration. The launch of this in November 2017 was attended by Bridgewater Academy schoolchildren. This appeared in the Bristol Post, Bristol Faces, [Bristol 247](#), 'Lab Design' magazine and on BBC radio. The lab was opened by Professor Andrew Nix, Dean of Engineering, in front of students, colleagues and distinguished guests, including representatives from Boeing, who sponsored some of the equipment. Professor Nix said: "We have a strong commitment to science and engineering here in Bristol, and this is a ground-breaking facility that makes a huge impact, we're making a statement that Bristol is a place for state-of-the-art teaching."
- *Leader University Space research group (2013-15)*
Organised a regular programme of space research meetings and seminars across all University faculties with participation from Science, Arts and Humanities, Engineering, Social Sciences and Law. This is an organisation of some 40+ members, and the workshops and seminars led to the formation of the University of Bristol Satellite Programme.

3.2. Academic leadership in the University

- *National Teaching Fellowship mentoring team (2020)*
As part of the National Teaching Fellowship selection board, I have reviewed candidate applications for selection for the NTF scheme for 2020. I am then mentoring one of the candidates meeting them regularly and feeding back on their application.
- *Academic Career Development Programme (ACDP) Management Group (2019)*
I have joined the University-level Management group of this initiative to update promotion and progression processes in the University. Here I am influencing the criteria and examples that are used in progression guidance to enable those passionate about teaching to be rewarded.
- *Review panel for Benjamin Meaker Visiting Professor and Researcher awards (2019)*
As a member of this cross-University panel of Professors, I review and select the awards for visiting the BM professor and researcher scheme. It involves reading and scoring the applications and agreeing them with the other members.
- *Member of Steering group for Bristol Institute for Learning and Teaching (BILT) (2016-2019)* -This steering group directs the new Institute which UoB has set up to support Learning and Teaching at UoB. I contribute to shaping the future policy and governance of BILT and participate in communicating its messages via roadshows and workshops. In the BILT committee, I work with the top minds in education in the

university and contribute to the delicate balancing act between the ambition for educational excellence and day-to-day practicalities of departments and schools. I help review applications for BILT funding, provide writing workshops for applications.

- *Established Teaching and Education forum (2014-2017)* – A few years ago there was a significant growth in student numbers in our School, and a consequent recruitment of many junior staff. This coincided with a hiatus just before the new CREATE scheme was launched. As a senior member of staff, I was encouraged to respond to this, so I developed a platform for the talents and experience of our senior staff and education innovators, which at the same time offered support and training for new and existing staff. This is called the Teaching and Education forum (TEf) and has now been running for 3 years. It consists of a series of seminars to showcase innovative and excellent practice ideas. These have covered exam question setting, using polling techniques to promote engagement, flipping the classroom, setting new coursework etc. Between twenty and thirty staff attended each of 6 discussions per year from 2014 to 2017. Staff who have attended the forum have gone on to implement the ideas in their practice and to become innovators and ‘Scholarship of Teaching and Learning’ researchers themselves. A comment from one of the attendees: *“I really appreciated the TEf sessions because they made it easy to meet inspirational people who were sharing their innovative teaching practices and striving for teaching excellence. Seeing presentations from people who believed in the importance of teaching, and some who were even having a career in teaching really motivated me. Having the opportunity to discuss teaching practice helped me to identify problems with my own teaching practice and find ways to improve student learning. I was even inspired to join the Faculty's first Learning Community and am writing up my project as a journal paper - neither of which I would have had the confidence to do without the influence and the support of the community of people who I met there.”* After leading this forum successfully for several years, I ensured the continuation of this group by mentoring a colleague to take over its leadership, which he has done very successfully. He has said: *“During the last year, Lucy has encouraged me to take the lead on organising this Teaching and Education Forum which has attracted many from leading professors to junior lecturers. Lucy's guidance and leadership have helped me strike a good balance between the formalities of delivering material during the sessions and that of also building community across those engaging with pedagogy, whilst also assisting me build my citizenship portfolio and credibility across the faculty.”*
- *Deputy Programme Director of Aerospace Engineering Degree (2015-present)* – In this role I attend Faculty Undergraduate Studies Committees, deputising for the Programme director. This has given me an overview of faculty-level education changes and priorities. I have encouraged the uptake by the committee of measures of improvement such as promoting inclusivity and encouraging wider participation in our engineering degrees via ‘Access’ courses. I felt very strongly about removing the mark rankings provided to students, with the aim of improving student mental health, and was delighted of the opportunity to advocate for it to departments and colleagues. Being involved in the yearly process of validation, monitoring and review of new and existing courses, is also an important role of this committee and it is vital that we continue this process when we rebuild the structure of Faculty and School Education committees.
- *Redesign of department tutorial system* – In 2015, in response to staff and student feedback, I led a rebuild of our department tutorial sessions. Together with students, I established learning objectives for these sessions and then built a structured series of

tutorials and study skills sessions for first year students. After a pilot study for a year, this structure was rolled out across the department. This work has now been incorporated into the Faculty semi-structured tutorial system.

- *Mentoring* – I informally mentor several colleagues including Laura Dickinson, Steve Bullock, Pia Sartor. A comment from one of them: *“I’ve experienced Lucy’s fantastic mentoring to lots of academics; she connects and is deeply interested in people. She seeks us out, asks us questions, listens to us, brings us together and urges us to action; she is rooting for us, she makes us feel empowered. And when we try to lead and to change, she is present, supporting our cause.”* (part of a winning entry to an Aurora competition to propose a female role model by Dr Laura Dickinson). Formally, I am mentoring a colleague in Earth Sciences to lead a commercial contract for the UK Space Agency on our University of Bristol Satellite payload (a Thermal InfraRed Imager) using industry experience.
- *Mentor on University Mentoring Scheme (2014-2015)* - mentored 3 early careers STEM discipline researchers with regular meetings and advice.
- *Member of CAME Athena Swan Committee (2015)* - For this submission, I was responsible for gathering qualitative data from the female members of staff – an assignment requiring diplomacy and influential writing skills. This contribution was instrumental in us successfully attaining the Bronze award.
- *University of Bristol Leadership training (2017)* – I was selected for two academic leadership courses: an EPSRC Career Development Programme provided by Skills UK and the University of Bristol’s Senior Academic Leadership Training. These programmes have helped me develop my skills in leadership. The trainer of the EPSRC programme described me in 6 words as: *“calm, confident, expert, influential, leader, strategic”*.

3.3. Indications of External Recognition

- Guest lecturer appt. at International Space University, Strasbourg (2019-present)
- Invited to speak at House of Lords Select Committee on impact of Brexit on UK Space Industry (2018)
- Keynote speaker at Pillinger lecture Lunar 50 years celebration (2019)
- Pint of Science, Bristol, speaker 2020
- Invited to be external examiner for UCL and Manchester 2019 (not accepted)
- Invited to University of Limerick for interview panel for recruitment (2019)
- Member of Space Academic Network (space policy pressure group)
- Invited by UK Space Agency to be a **Skills panel** member at UK Space Conference (2017) to debate on: *“There is no skills gap – discuss”*.
- Invited talk to Space Action Network **policy advisory committee for Govt.** (2017)
- Invited talk to the International Astronautical Congress Education Committee, (2018)
- Invited to be **convenor for new Engineering Professors Council’s** ‘Engineering Academics Network’ (2017) (not accepted)
- **External Examiner** for PhD for University of Manchester (2017)
- Invited External Examiner for Kingston University (2016) (not accepted)
- Invited External Examiner for UWE (2015) (not accepted)

- **Guest Space lecturer** in Space Systems at UWE Aerospace Department 2012-2016
- Academic representative on **International Judging panel** for Frank J. Redd Student competition at SmallSat conference (the top CubeSat conference in the world) 2018
- Member of Judging panel for UK Space Agency “Space Education and Outreach Grants” 2014
- Invited by a **NASA space engineering training company**, TSTI Inc., to provide training to European spacecraft manufacturing companies for them (not accepted)
- Member of the **European Society of Engineering Education committee** on Diversity and Inclusion
- Invited European Union H2020 reviewer for Space grant funding (not accepted)
- Invited **Chair** of annual Colin Pillinger Memorial Talk 2017
- Invited talk on Planetary Protection at University of Cranfield 2017 (not accepted)
- Invited Royal Aeronautical Society talk February 2017
- Invited Royal Astronomical Society talk April 2017
- Invited **Keynote speaker** UK Student Space Conference speaker March 2017

3.4. Professional Activities Outside the University

I have worked part-time (1 day a week) at a spacecraft manufacturer called Thales Alenia Space UK since 2012. Here I am a Project Manager for research grants awarded by the European Space Agency, the EU and the UK Space Agency. As project manager, I perform the following management tasks:

- Managing the finances of projects
- Negotiating the contract with the customer and commercial departments
- Arranging and chairing progress meetings with the customer and the academic and industrial collaborators (approximately 6 one-day meetings per year for the 3 projects on which I am Project Manager)
- Coordinating the technical efforts of staff at Thales Alenia Space UK and collaborating institutions and subcontractors
- Liaising with procurement team and commercial dept to procure hardware
- Ensuring the deliverables are produced to time and to budget
- Managing the dissemination of research results through journals and conferences
- Ensuring the continuing professional development of staff by, for example, devolving some management tasks to experienced engineers.
- Mentoring 6 early careers staff.

Highlights of my career as a professional space systems engineer:

- *Mars Sample Return mission work for Thales Alenia Space UK (2014-2018)*
Project manager and technical lead for £1.1 million of European Space Agency and EU Horizon 2020 research contracts to develop a specialised Earth Facility, robotics and isolator equipment for rocks brought back from Mars in future Mars sample return missions. This work is vital for the protection of Earth from possible Martian biological material.
- *European Space Agency Nanosatellite Project for Thales Alenia Space UK (2013-15)*

Project manager of a team of European subcontractors for a £200K European Space Agency contract to develop a nanosatellite design. This project is now been mounted on an airborne demonstrator for a pollution-monitoring satellite constellation.

- *Low altitude Satellite design for Thales Alenia Space UK (2012-2014)*
Technical lead for a low altitude satellite design with Synthetic Aperture Radar and hyperspectral payloads. This project is ongoing and has had ESA, DSTL and TAS funding. TAS has funded a PhD student on this topic, which I supervise.
- *Mars Express space craft for Airbus Defence and Space*
I was the instrument engineer at the beginning of the Mars Express spacecraft project. This spacecraft has been orbiting Mars since 2003 and has sent back unparalleled science data. It is still operating and is one of the most successful European Space Agency missions ever.
- *Spacecraft debris shield design research for Airbus Defence and Space (1999-2000)*
I was the project manager of a multi contractor team for a 250KEuro European Space Agency contract to produce simulation models for spacecraft debris shields. These are shields consisting of multiple layers to break up space debris and micrometeoroids when they impact spacecraft and space stations.
- *Strategy and technology development for Airbus Defence and Space (1997-2003)*
I was the senior engineer responsible for strategy and technology development, assessing current and future technologies and building links with Universities.

3.5. Contributions to Society

- Governor at Christ Church Primary School 2010-2013, head of School Improvement Committee. Responsible for taking the school through its last OFSTED inspection successfully.

3.6. Good citizenship

As well as my more formal mentoring, I help staff and students in the Faculty whenever possible e.g. by providing students and staff with space career advice (I keep a list of questions asked by large space companies). I also do teaching peer observations, review PhD students for progression and advise students from other disciplines about space projects. I regularly support Open Days and have sat on interview panels to appoint staff in the Faculty. As a more experienced member of the department, I particularly value my pastoral role with students and early careers colleagues and have several times been given the management of students with particularly complex needs, such as multiple extenuating circumstances combined with severe depression or complex health problems. This has involved regular meeting with the students and liaising with the University legal, health and Vulnerable Student services to help support them.

3.7. Outreach

As a female space engineer, I am frequently in demand as a role model for school children and have participated in 70+ outreach events for schools. These have ranged from primary school satellite-building workshops to 6th form taster days, University Open days, 'Inspire' days for women, Royal Aeronautical Society's 'Cool Aeronautics'

project, Sutton Trust workshops. After my selection for a 'Best of Bristol' lecturer award in 2015, the invitations for me to speak began to snowball. For example, one week I was invited to give a TEDx talk in Singapore then to introduce the film 'Hidden Figures' at the Bristol Watershed cinema to an audience of 100 KS3 schoolgirls, as part of International Women in Engineering day. I have given talks at the Royal Aeronautical Society, the Royal Astronomical Society, Bristol's Pint of Science talks, At-Bristol and Cafés Scientifiques. A highlight was giving a TEDx talk at the University of Bristol TEDx event in 2016 which has since had 3200 views. I am BBC Radio Bristol's 'resident space expert', being interviewed regularly about space subjects in the news. I have recently helped organise a regular South West regional finals of the European Space Agency CanSat competition for schoolchildren to build a satellite in a SodaCan.

4. Future Plans

This cv demonstrates that I am acting as a professional role model in the areas of teaching, scholarship of teaching and learning, and space engineering. I would like to gain greater knowledge about the workings of the higher levels of the University, through membership of committees on education matters. I am getting further involved with the strategic initiatives in education which the University is undertaking, including programme-level assessment, improving promotion procedures and BILT. I would like to see through the CAME First Year curriculum review to a successful implementation in 2021. I am also hoping this year to apply for a Principal Fellow of the HEA (the top level) which would bring further prestige to the University, as well as my National Teaching Fellowship. Professors are well placed to give back to the University, its stakeholders and its surrounding community and I am enjoying doing this. I love encouraging early careers colleagues and being an ambassador for the University of Bristol.

Appendix A: Publications list

Journal articles before August 2018

1. **Berthoud, L.**, and Gliddon J. (2018). "[Using wikis to investigate communication, collaboration and engagement in Capstone engineering design projects.](#)" *European Journal of Engineering Education*, Vol 43, issue 2 (90%)
2. **Berthoud L.** and Glester A. (2017) "Developing a Network to support the Space Engineering Higher Education Community", *Educating the Educators, International Journal of Engineering Education*, Vol 34, Issue 2, 2018. (95%)
3. Turner R.J., Taylor E. A. McDonnell J.A.M, Stokes H., Marriott P., Wilkinson J., Catling D.J., Vignjevic R, **Berthoud, L.**, and Lambert M (2001) "[Cost effective honeycomb and multi-layer insulation debris shields for unmanned spacecraft](#)". *International Journal of Impact Engineering*, 26 (1-10). pp. 785-796. ISSN 0734-743X (10%)
4. Cintala M.J., **Berthoud L.**, Hörz F. (1999), "[Ejection-velocity distributions from impacts into coarse-grained sand](#)", *Meteorit. Planet. Sci.* 34, 605–623 (90%)
5. Drolshagen G., Carey W. C., McDonnell J. A. M., Stevenson T. J., Mandeville J. C., **Berthoud L.** (1997) "[HST solar array impact survey: Revised damage laws and residue analysis](#)" *Advances in Space Research*, Volume 19, Issue 2, 1997, Pages 239-251 (90%)
6. **Berthoud L.**, Mandeville J.C. (1997) "[Low Earth Orbit micrometeoroid and debris investigations](#)", *J. Spacecraft and Rockets*, Vol. 34, No. 1, January–February 1997. (95%)
7. **Berthoud L.**, Mandeville J.C. (1997) "[Material damage in space from microparticle impact](#)", *J. Materials Science*, 32, 3043-3048 (95% input)
8. **Berthoud L.**, Paul K. (1997) "[Meteoroid and debris micro-impacts on space-exposed solar arrays](#)", *Advances in Space Research*, Volume 20, Issue 8, 1997, Pages 1441-1445, (80%)
9. **Berthoud L.**, Cintala M.J. & Horz F. (1997) "[Ejecta Velocities from Impact Craters in Sand](#)", *Meteoritics & Planetary Science*, vol. 32, page A13, 1997 (90%)
10. Mandeville J. C., **Berthoud L.** (1995) "[From LDEF to EURECA: Orbital debris and meteoroids in low earth orbit](#)", *Advances in Space Research*, Volume 16, Issue 11, 1995, Pages 67-72. (95%)

Conference articles before August 2018

1. **Berthoud L.** et al. (2018) Sample Transport for a European Sample Curation Facility, *2nd ESA Mars Sample Return Symposium, Berlin, April 2018.* (95%)
2. Vrublevskis, J.; **Berthoud, L.**; Guest, M.; Smith, C.; Bennett, A.; Gaubert, F.; Schroeven-Deceuninck, H.; Duvet, L.; van Winnendael, M. (2018) [Description of European Space Agency \(ESA\) Concept Development for a Mars Sample Receiving Facility \(MSRF\)](#), *2nd ESA Mars Sample Return Symposium, Berlin, April 2018.*
3. Vrublevskis, J.; **Berthoud, L.**; McCulloch, Y.; Bowman, P.; Holt, J.; Bridges, J.; Bennett, A.; Gaubert, F.; Duvet, L. (2018) [Description of European Space Agency \(ESA\) Double Walled Isolator \(DWI\) Breadboard Currently Under Development for Demonstration of Critical Technology Foreseen to be Used in the Mars Sample Receiving Facility \(MSRF\)](#), *2nd ESA Mars Sample Return Symposium, Berlin, April 2018.*
4. **Berthoud L.** and Pugh K. (2017), 'Setting up a Community of Practice for a university CubeSat programme', *Proc. Higher Education Academy STEM Conference, Newcastle, January 2018.*
5. Russell, S. S. and Smith, C. L. and Hutzler, A. and Meneghin, A. and Brucato, J. R. and Rettberg, P. and Ferrière, L. and Bennett, A. and Aléon, J. and Gounelle, M. and Franchi, I. A. and Westall, F. and Foucher, F. and Zipfel, J. and **Berthoud, L.** and Vrublevskis, J. and Grady, M. and the EURO-CARES Consortium (2017), '[Euro-Cares \(European Curation Of Astromaterials Returned From Exploration Of Space\): An Update.](#)' *48th Lunar and Planetary Science Conference 2017, 20-24 March 2017, The Woodlands, Texas.*
6. **Berthoud, L** & Walsh, J, (2017), '[Using mission analysis software GMAT to develop skills in astrodynamics](#)'. in: *Proceedings of the 45th SEFI Annual Conference 2017 - Education Excellence for Sustainability, SEFI 2017.* European Society for Engineering Education (SEFI), pp. 1116-1123

7. Walsh J.A. and **Berthoud L.** (2017), '[Reducing spacecraft drag in Very Low Earth Orbit through shape optimisation](#)', 7th European Conference For Aeronautics And Aerospace Sciences (EUCASS), Rome DOI: 10.13009/EUCASS2017-449.
8. **Berthoud L.** and Schenk M.(2016) '[How to Set Up a CubeSat Project – Preliminary Results](#)', *Education session in 30th Annual AIAA/USU Conference on Small Satellites August 2016*. American Institute of Aeronautics and Astronautics Inc.
9. Walsh J. and **Berthoud L.** (2016) 'Is it possible to integrate Electric Propulsion thrusters on Very-Low Earth Orbit Microsatellites?' *Proceedings of Space Propulsion 2016 conference, 2-6 May 2016*, Rome.
10. Hutzler, A. Ferrière L., Smith C. L., Russell S., Aléon J., **Berthoud L.**, Brucato J.R., Gounelle M., Grady M. and the EuroCares Consortium. (2016) '[Euro-Cares: Project Roadmap of a European Sample Curation Facility](#)', *47th Lunar & Planetary Science Conference*, 21-25 March 2016, The Woodlands, Texas.
11. Stables J. and **Berthoud L.** (2015) 'Thermal Control of Propulsion-Capable CubeSats', *Proceedings of 7th European CubeSat Symposium*, Liege, Belgium.
12. Wertheimer E., **Berthoud L.** Johnson, M. (2015), 'PocketRTG – a CubeSat scale radioisotope thermoelectric generator using COTS fuel.' *Proc. 4th Int. CubeSat Workshop* at Imperial College, May 2015.
13. **Berthoud, L** and Phillips, J. (2013), 'Deployment systems for 50+ CubeSats'. in: *Proceedings of 64th International Astronautical Congress, Beijing, China*.
14. **Berthoud, L**, Naudet, J, Kassel, R, Parfitt, C & Bacon, A (2013), 'Design and development approach for a highly capable standard nanospacecraft'. *Proceedings of the 64th International Astronautical Congress, Beijing, China*.
15. **Berthoud, L**, Schroeven-Deceuninck, H, Vrubleviskis, J, Guest, M, Smith, C, Grady, M & Bridges, J (2013), 'Concept for a Lunar and Asteroid Sample Return Facility'. in: *Proceedings of the 64th International Astronautical Congress, Beijing, China*.
16. Grasso A. **Berthoud L.** (2012) 'Ultra-Low Earth Observation Satellite', *Proc. International Astronautics Congress, Naples, Italy*.
17. Hillier F. Van Hoof R. **Berthoud L.** (2012) "Power & Thermal Design of Europa & Ganymede Penetrators", *Proc. Int. Planetary Probe Workshop, Toulouse, 2012*.
18. Nouvellon, S. **Berthoud L.** Rickwood W. (2012) "Thermal design of a Lunar Penetrator", *Proc. Int. Planetary Probe Workshop, Toulouse, 2012*.
19. **Berthoud L.** Hobbs J. Pillinger C.T. and Sims M.R. (1998) "Systems design of Beagle-2: A Lander for Mars", *Proc. AIAA Conf. on Low Cost Planetary Exploration Missions, Pasadena 1998*
20. **Berthoud L.** Cintala M.J. and Horz F. (1997).[Velocity determination for ejecta from craters in coarse-grained sand](#)) *Lunar Planetary Science XXVIII*, 103-104
21. **Berthoud, L.** Mandeville, J. C. (1997) "Distinguishing Between Oblique Incidence and Non-Spherical Projectile Impacts", *Second European Conference on Space Debris, 17-19 March, 1997, ESOC, Darmstadt, Germany, ESA-SP 393.*, p. 487
22. **Berthoud L.** (1995) "[Microimpacts on HST solar array 1 surfaces](#)", *Proc. HST workshop, ESTEC Noordwijk, May 1995*.
23. **Berthoud L.** and Paul K. (1995) "Micro-impacts on Solar Array Surfaces", *Int. Workshop on Orbital Space Debris, pub. Gordon & Breach, 9-11 October, Moscow*.
24. **Berthoud, L.** Mandeville, J.C., Durin, C. Borg, J., (1995) "Debris and meteoroid proportions deduced from impact crater residue analysis", *LDEF: 69 Months in Space. Third Post-Retrieval Symposium, Part 1 p 431-444 (SEE N95-23796 07-99)*.
25. **Berthoud L.**, Mandeville J.C (1995) "Micrometeoroids and debris on LDEF comparison with MIR data", *LDEF: 69 Months in Space. Third Post-Retrieval Symposium, Part 1 p 275-285 (SEE N95-23796 07-99)*
26. **Berthoud L.**, Mandeville J.C. "[Analysis of remnants found in LDEF and MIR impact craters](#)", *AIP Conf. Proc. -- July 15, 1994 -- Volume 310, pp. 313-328*
27. **Berthoud L.** (1994) "[Microimpacts on EURECA solar panels](#)", *Proc. 6th Int. Symp. Materials in a Space Environment, ESTEC Noordwijk, September 1994*.
28. **Berthoud L.** and Mandeville J.C. (1993) "Further analysis of remnants found in LDEF and Mir impact Craters", *Interplanetary Dust Particle Workshop, Lunar and Planetary Institute, Houston, May 1993*.
29. **Berthoud L.** and Mandeville J.C. (1993) "Orbital Debris and Meteoroids: results from retrieved space experiments. First European Conference on Space Debris, Proceedings of the Conference held 5-7 April 1993 in Darmstadt, Germany. Edited by W. Flury. Paris, France: European Space Agency, 1993, p. 201 – 205.

30. **Berthoud L.** and Mandeville J.C. (1993) "Empirical impact equations and marginal perforation", *Proc. 'First European Conference on Space Debris', ESOC (European Space Operations Centre) Darmstadt, April 5 - 7, 1993.*